X-RAY INDUCED SEMISTERILITY OF RICE NOT INVOLVING CHROMOSOME ABERRATIONS EASILY DETECTABLE BY CYTOLOGICAL MEANS[1]

by

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Various workers (1, 4, 7, 8, 9, 12, 13, 14, 18, 19, 22, 24, 25) reported the occurrence of semisterility in rice induced by irradiation. The frequency of semisterile and sterile plants, appeared in the progenies of irradiated populations, was known to be the highest among all types of mutations found. The low seed-set showed such a close association with chromosome interchange that some researcher (22) even concluded that the semisterility could be a useful criterion for determining the occurrence of a heterozygous reciprocal translocation in the absence of cytological examination. It seems that the semisterility of radiation origin is not entirely due to translocation which is cytologically detectable, since the segregation for fertility in the progenies from irradiated plants is not as simple as that is expected by the interchange hypothesis only (1). Very few is known on the radiation-induced. semisterility of rice that does not involve chromosome aberrations. The nature of hybrid sterility in rice species has been controversial for a decade. Evidences in favor of both genic hypothesis and cryptic structural changes were presented by various workers, based on the observations on hybrid materials between existing varieties (23). It is a widely recognized concept that mutants constitute the principal raw materials for differentiation of living things. However, less effort has been made to clarify the nature of semisterility in rice, including those in hybrids of existing varieties, through the use of irradiated materials. Reported below are the results of a study on the X-ray induced semisterility of rice not due to big chromosome aberrations. This study was financially supported in part by the National Council of Science Development to which the writers wish to express their gratitute.

Materials and Methods

Dormant seeds of rice variety, Taichung 65, were treated with 10 kr, 20 kr and 30 kr of X-rays at 120 KVP in 1959. In the X_2 generation, the plants of various degrees of seed-set were harvested in a random manner from each treatment to provide the seed for progeny-testing. Twenty to 50 plants constituted a X_3 line. From 87 X_3 semisterility segregating lines, 22 lines were selected and used in this study. Semisterile plants of these lines had PMCs containing a ring or chain of four chromosomes at diakinesis and metaphase-I with a frequency equal or less than 3%. One to several representative sterile

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plants in each of 22 X_3 lines were progeny-tested, and several fertile plants in each of these progenies were testcrossed on the original variety, Taichung 65, to isolate the semisterility homozygotes. Besides, the seed-fertility of the testcross F_2 was investigated. The isolated semisterility homozygotes were progeny-tested, and only those that bred true were intercrossed in order to study the breeding behavior of seed fertility in the F_1 and F_2. The detail of pedigree of the materials used in this study is shown in Fig. 1. Ordinary smear method was employed in preparing the slides for cytological observations.

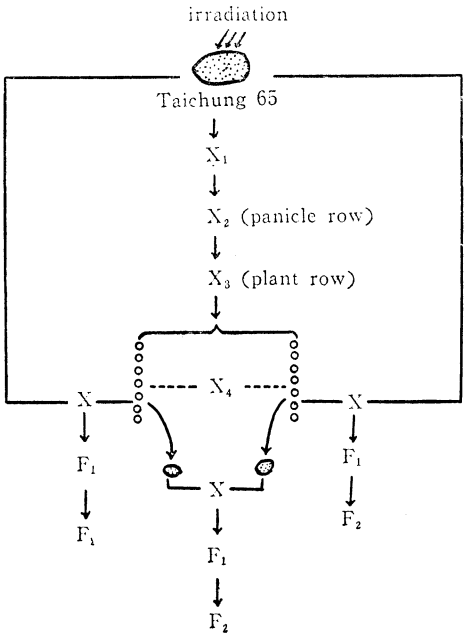

Fig. 1, The pedigree map of the materials used in this study

Results and Discussion

The frequency of PMCs containing ring or chain of four chromosomes in several semisterile plants in each X_3 line and the fertility of all plants in each of 87 X_3 lines were investigated and recorded. The ring or chain of four will be denoted by ④ hereafter. As a general rule, 15 to 30 PMCs at diakinesis and metaphase-I per plant were observed. Based on the cytological information, these X_3 lines were divided into two groups ; one group was the lines in which semisterile plants showed a ④ frequency more than 3.0%, and the other was those lines which the sterile plant had a ④ frequency equal or less than 3.0%.

In addition, the X_3 lines were arbitrarily classified into four categories according to the patterns of seed-fertility segregation. They were (A) continuously segregating, (B) segregating a few semi-sterile plants, (C) all semisterile with a few fertiles, (D) segregating into a ratio of one to one. The number of lines in each group and each category is shown in Table 1.

Table 1. Segregation patterns of seed fertility and the occurrence of ④ chromosomes in various X_3 lines

Segregation pattern / ④ frequency	A	B	C	D	Total (%)
④≦3.0%	10	2	1*	9	22 (25.3)
④>3.0%	5	1	4	44	54 (62.1)
Unknown	3		1	7	11 (12.6)
Total (%)	18 (20.7)	3 (3.4)	6 (6.9)	60 (69.0)	87 (100.0)

*Sterile plants of this line showed a normal pollen ratio

Note : A=Continuously segregated

B=Fertile with a few semisterile plants

C=Semisterile with a few fertile plants

D=1 : 1 segregating

Among 76 X_3 lines examined cytologically, an unexpected high number of 22 lines segregated only semisteriles of which PMCs contained one ④ at diakinesis or metaphase-I in a frequency equal or less than 3.0%. The frequencies of seed-fertilities in these lines distributed mostly in a continuous manner, A category, otherwise in one-to-one ratio, D category.

It is noteworthy that the lines belonging to A category tended to have low frequency of ④, while those lines segregated almost into 1 : 1 ratio tended to have high frequency of ④. Apparently big change in chromosomal strucure, especially reciprocal translocation, occurred in the lines belonging to the latter category. The chromosomal change in those lines with low frequency of ④ was naturally small. The frequencies of ④, found in the PMCs of semisterile plants of 76 X_3 lines are shown below.

0%	≦3.0	6.75	15	25	35	45	55	65	75	85	95	Total
Number of lines	22	4	5		4		3	5	6	9	18	76

Among those lines showing a ④ frequency more than 3.0%, there was a significantly negative correlation, $r=-0.298$, between ④ frequencies and the seed-fertility of semisterile segregates. No such correlation was found in the 22 lines showing ④ frequency less than 3.0%.

In order to clarify futher the relationship between ④ frequency and seed-fertility in low ④ group, four representative lines, namely X_3-2, X_3-28, X_3-57 and X_3-70, out of the 22 lines were examined thoroughly on an individual-plant basis. Fifteen to 30 PMCs per plant at diakinesis and metaphase-I were observed . The number of plants investigated in each line and the average frequency of ④ in fertile and in semisterile plants in each line are presented in Table 2. One semisterile plant in X_3-57, that had an unexpectedly high percentage of ④, was excluded in the averaging.

Table 2. Frequencies of ④ chromosomes in four X_3 lines segregating for semisterility

Line number	No. of plants* investigated	No. of plants showed④	Ave. % of ④ forming PMCs in fertile plants	Ave. % of ④** forming PMCs in semisterile plants	Segregation pattern for seed fertility
X_3—2	21	2	0.52(1/190)	0.35(1/280)	A
X_3—28	30	12	1.63(3/184)	2.91(17/583)	A
X_3—57	38	8	1.23(5/404)	1.77(10/563)	D
X_3—70	25	7	0.84(3/354)	3.00(9/300)	B

* Including fertile and semisterile ones

** A seed fertility less than 75% was considered semisterile.

The percentage of PMCs having ④ in fertile or normal plants of these four lines was 1.6%, or less. All of these PMCs contained only one ④. This result corresponds roughly with those reported by Sakai (20), about one percent in Japanese varieties, and by Huang *et al.* (7), 1.5% in Taichung 65. Hsieh (5) and Demeterio *et al.* (2) also reported the occurrence of ④ in the ordinary cultivars. The semisterile plants in X_3-28 and X_3-70 showed slightly higher frequency of ④ than that in the fertiles. The difference in the frequencies between fertile and semisterile plants in other two lines was probably not significant.

In the remaining 18 lines, the frequency of ④ was very low, though the number of PMCs examined in each line ranged between 25 and 80 collected from several semisterile plants. No ④ was found in 15 lines and 1.3%, 1.7%, and 2.95 were obtained in the remaining three lines. The quadrivalent, though in a very low frequency, appeared in the PMCs of fertile plants, or in the original normal variety, or in other cultivars, is difficult to explain. A translocation of very small segments which are genetically inert, occurring at terminal regions of different chromosome arms, may result in such a cytological consequence. However, the ring of four will be eliminated after several successive selfings. Whatever the origin of ④ in the normal plants may be, it is difficult to distinguish it from the ④ possibly caused by translocation of small segments induced by irradiation. Pachytene analysis, which is still somewhat controversial in its amendability in rice, may be useful for further clarifying this. In any way, the lines having ④ in a frequency equal or less than 3.0% may be considered as the ones having normal chromosome structure or cryptic structure change of chromosomes in conventional cytological terms. These lines will be tentatively called no ④ lines, while those showed high ④ frequency will be called ④ forming lines hereafter.

One to several representative semisterile plants were selected from each of the so-called no ④ lines for progeny-testing. The relationship between the segregation parrerns of seed fertilities in the X_3 and those in the X_4 is shown in Table 3.

Semisterile plants from 1 : 1 segregating X_3 lines tended to produce progenies also segregating into 1 : 1, while those from continuously segregating X_3 lines produced progenies

Table 3. The relationship of segregation patterns of seed fertility between X_3 and X_4 lines showing ④ less than 3.0% (numbers in the Table show the numbers of X_4 lines)

X_4 \ X_3	A	B	C	D	Total
A	14	1			15
B	2	1		3	6
C	3		4		7
D	2		1	12	15
Total	21	2	5	15	43

of all four categories of segregation with a tendency toward the continuous pattern. It is conceivable that the factors responsible for the semisterility in the continuously segregating lines are more complicated than those in the lines segregating 1 : 1.

From most of these X_4, 3 to 5 fertile plants per line were selected and testcrossed with Taichung 65, resulting in the successful isolation of 14 homozygotes of semisterility derived mostly from different X_3 lines (Table 4).

Table 4. Testcrosses of the fertile plants within semisterility segregating lines having ④ frequency less than 3.0%

F_1 No.	Parent			Chromosomes* in PMCs	Average seed fertility (%)
	♀	♂ (progeny test)	Segregation type in X_4 line		
259	Taichung 65	X_4 609—4 (S)	1 : 1	12II	54.8
266	〃	X_4 611—3 (F)	1 : 1	〃	52.0
268	〃	X_4 612—3 (F)	1 : 1	〃	48.0
286	〃	$X_4$617—11 (F)	1 : 1	〃	48.1
290	〃	X_4 618—8 (S)	Cont.	〃	?
310	〃	X_4 623—2 (F)	1 : 1	〃	47.9
316	〃	X_4 624—8 (F)	1 : 1	〃	44.4
322	〃	X_4 627—8 (F)	Cont.	〃	58.2
326	〃	X_4 629—1 (F)	Cont.	〃	64.8
354	〃	X_4 636—5 (F)	1 : 1	〃	53.0
371	〃	X_4 644—4 (F)	1 : 1	〃	47.3
374	〃	X_4 645—4 (F)	Cont.	〃	62.5
385	〃	$X_4$650—1 (F)	1 : 1	〃	44.5
390	〃	$X_4$652—11 (F)	Cont.	〃	63.8

Note : (S) indicates segregation of semisterility in the progeny.
(F) indicates no segregation determined by visual observation.
* Determined based on 20—30 PMCs at diakinesis and metaphse—I.
? One plant with 30% fertility and 3 plants almost normal.

The average seed-fertilities of the testcrossed F_1's in Table 4 were obtained from one to several F_1 plants. The seed-fertilities of these F_1 plants were compared in Table 5 with those testcross F_1's of which parental lines showed high frequencies of ④ and segregated into 1 : 1 ratio for fertility. However, only those testcross F_1's that had a seed-fertility less than 75% were included.

It is shown in Table 5 that the testcross F_1's of fertile plants from the lines forming ④ and segregating for seed-set in 1 : 1 ratio had a seed-fertility ranging from 59% to 30% with an average of 42.3%, while those from the lines segregating into 1 : 1 but without ④ formation ranged from 59% to 40% with an average of 49.3%. On the other hand, the testcross F_1's of the fertile plants from the line segregated continuously but without ④ formation had a higher range, 75% to 50%, of seedset distribution with an average of 66.3%. These results lead to a conclusion that the degree of sterility was related with segregation patterns and ④ formation.

Table 5. Percentages of seedset in the testcross F_1's between original Taichung 65 and the fertile plant in X_4 semisterility lines showing no ④ ($\leq$3.0%)

Nature of ♂ parent line	♀ parent	Seed-fertility (%)							Total number of testcrosses
		85	75	65	55	45	35	25	
Forming ④ and 1 : 1 segregated	Taichung 65				1	27	12		40
No ④ but 1 : 1	〃				6	9			15
No ④ but continuously segregated	〃		1	10	2				13
No ④ but other segregation pattern	〃			1	1	1			3

The 31 testcross F_1's of the fertile plants from no ④ lines shown in Table 5, were also cytologically investigated. Most of them did not form ④ in the PMCs at diakinesis and metaphase-I, except 6 F_1's which showed a ④ frequency ranging from 27.8% to 31.6%, despite the fact that no ④ was observed in their female parental lines. Of these 6 F_1's, 4 were related with continuously segregating lines originated from two different X_3 lines. The female parental lines of other 2 F_1's were of other segregation types than 1 : 1.

In the meantime, not all of the F_1 plants in a testcross gave the similar degree of seed-setting, though a majority of the F_1's did so. This is shown in Table 6. Differences in seed setting percentages of F_1 plants in the same testcross could be attributed to the environmental factors or possibly due to self-pollination during hybridization or even due to mixture. The rate of self-pollination in hot-water emasculatrion was very low and the F_1 plants were carefully grown in the field ; moreover the fertile F_1 plants in other testcrosses, grown in the same field, showed a seed-fertility higher than 75%. Thus, the genetic cause of such segregation is more likely, though its nature is still obscure.

Table 6. Segregation of seedset in three testcross F_1's of the fertile plant in X_4 lines segregating for semisterility and showing no ④

F_1 No.	Parent		Seed fertility (%)										Total
	♀ ♂	(fertility)	95	85	75	65	55	45	35	25	15	5	
F_1 296	Taichung 65	620—4 (96.2)	9	2	1	2		1					15
F_1 302	〃	621—5 (84.0)	3		1					1		1	6
F_1 343	〃	633—8 (99.1)	5	1		2					1		9

The testcross F_1's which were semisterile but did not form ④ in PMCs were progeny-tested. About 20 to 40 F_2 plants constituted a progeny. The distribution patterns of seed-fertility in each of 14 testerosses are presented in Table 7.

Table 7. Frequency distribution for percentage of seedset in the testcross F_2's between original Taichung 65 and the fertile plant in the X_4 lines segregating for sterility and showing no ④

F_2 No.	Parent		Ave. seed set of TCF_1 (%)	Number of TCF_2 plants in each seed set range									
	♀	♂		95	85	75	65	55	45	35	25	15	Total
259	Taichung 65	609-4	54.8	16	8	1	2	5	10	2			44
266	〃	611-3	52.0	13	3		3	7	12		1		39
268	〃	612-3	48.0	12	6	1		3	13	2			37
286	〃	617-11	48.1	17	10	2	1	8	6				44
290	〃	618-8	?	25	2	10	7						44
310	〃	623-2	47.9	20				11	12	1	1		45
316	〃	624-8	44.4	8			1	6	11	1			27
322	〃	627-8	58.2	17	4	3	7	8	1				40
326	〃	629-1	64.8	23	5	13	4						45
354	〃	636-5	53.0	15	8	1	3	8	5	2			42
371	〃	644-4	47.3	15	6			4	14	5			44
374	〃	645-4	62.5	10	9	10	21	1					51
385	〃	650-1	44.5	18	4	3		2	10	1			38
390	〃	652-11	63.8	1	6	8	1	1					17

Only F_2's 286, 316, 374 and 390 in Table 7 did not agree with the expected 1 : 1 ratio in seed-fertility ; apparently F_2's 374 and 390 were continuously segregated. It is worthy to

note that most of the semisterile plants in F_2's 290, 326 and 374 had a seed-fertility ranging between 60% to 75%.

The above results indicated that the X-ray induced semisterility not due to big chromosome changes could be perpectuated in the fertile homozygous forms and could be reproduced by backcrossing them to the original variety. These homozygotes, tentatively designated as SH lines, did not show any distinct difference in qualitative characters from the original Taichung 65.

Twelve SH lines that bred true were selected in the next season and the intercrossings were made between them. Summarized in Table 8 are the seed-fertilities and pollen ratios of the intercross F_1's from 6 SH lines. It can be seen in the Table that the seed-fertility varied from 14.9% to 42.3%. One thing worth mentioning is that the F_1 between SH629-1 and SH652-11, that derived from the lines segregated the partial sterile plants relatively high in fertility, gave a seed fertility as high as 42.3% (Table 7).

Table 8. Percentages of good and intermediately aborted pollens (in parentheses) and seedset (above the diagonal line) of the intercross F_1's among SH lines

♀ \ ♂	SH 629-1	SH 636-5	SH 644-4	SH 654-4	SH 650-1	SH 652-11
SH 629-1	—	24.2	27.9	37.0	24.7	42.3
SH 636-5	50.9 (0.1)	—	14.9	25.0	18.2	35.7
SH 646-4	45.8 (0.1)	42.2 (0.2)	—	27.7	—	32.9
SH 645-4	47.5 (3.9)	39.6 (2.7)	43.2 (1.1)	—	19.0	—
SH 650-1	45.6 (12.5)	38.2 (16.1)	31.9 (8.7)	38.8 (14.2)	—	24.3
SH 652-11	48.7 (0)	50.0 (0.4)	44.3 (2.2)	—	48.7 (9.1)	—

On the other hand, the seed fertilities of the intercross F_1's were apparently lowered by the combination of two sources of sterilities. The degree of lowering depended on the degree of sterility from the two sources. It is indicated in Table 9 that the observed fertilities of the F_1's agreed with the calculated values in a majority of the testcrosses. Hence, the sterilities were recombinable.

Double translocation heterozygotes, which involved high frequencies of ring of six or two rings of four chromosomes, were reported to have seed fertilities as low as 3% or less (7). In other words, they were almost completely sterile, consequently no double translocation homozygotes could be recovered in their offsprings.

Table 9. Observed and calculated seed fertilities of the F_1's between SH lines

P_1 line		P_2 line		F_1 seed-fertility	
SH No.	Average seed fertility of semisterile plant	SH No.	Average seed fertility of semisterile plant	Observed	Calculated (P_1XP_2)
	(%)		(%)	(%)	(%)
SH 636-5	53.0	SH 629—1	64.8	24.2	34.3
〃 644-4	47.8	〃	〃	27.9	30.9
〃 645-4	62.5	〃	〃	37.0	40.5
〃 650-1	44.5	〃	〃	24.7	28.8
〃 652-11	63.8	〃	〃	42.3	41.3
〃 644-4	47.8	SH 636—5	53.0	14.9	25.3
〃 645-4	62.5	〃	〃	25.0	33.1
〃 650-1	44.5	〃	〃	18.2	23.5
〃 652-11	63.8	〃	〃	35.7	33.8
〃 645-4	62.5	SH 644—4	47.8	27.7	29.8
〃 652-11	63.8	〃	〃	32.9	30.4
〃 650-1	44.5	SH 645—4	62.5	19.0	27.8
〃 652-11	63.8	SH 650—1	44.5	24.3	28.3

Relatively high fertility of the intercross F_1 between SH lines will make it possible to combine two genetic sources of semisterility in a homozygote form that will eventually be fertile and breed true. On the contrary, no such combining is possible in the case of double translocation heterozygotes, not only because of their extremely low seed fertility but also because of the lethal effect of the male gametes carring two translocations (7). The intercross F_1's between SH lines also differed from the double translocation heterozygotes by that they did not produce the parthenocarpic-like spikelets.

The good pollen ratios of the intercross F_1's, presented in Table 8, ranged from 31.9% to 50.0% which were also considerably higher than those found in the ring of six or two rings of four double translocation heterozygotes, averaging 20%-30% (7). In addition, these F_1's had intermediately aborted pollens which were never observed in the translocation experiments conducted by the authors (7). This phenomenon has been frequently reported in the F_1's of the intersubspecific hybrids of cultivated rice.

The percentages of intermediately aborted pollens in various intercross F_1's were found most frequent between 0%-3% and 10%-15%, depending somewhat on parental SH lines. For example, the F_1's related with SH650-1 were always high in the percentage (Table 8). These aborted pollens could be a result of artifact during the preparation of slides, or due to some kind of genetic factor, or both.

The F_2 populations of intercrosses between SH lines were tested for segregation of seed fertility and good pollen ratio. Table 10 shows the results. The frequency of seed

fertility in most of the F_2's distributed in a continuous pattern with wide range from 5% to 95%. Without exception, the average fertility of the F_2 was higher than the average of the F_1 in the same cross. Good pollen ratio also showed the similar segregation, only the range was narrower. It is apparent that two sources of semisterility simultaneously segregated, consequently the sterility characteristic of the F_1 was almost lost in the F_2. The similar segregation of fertility has been commonly reported in the intersubspecific hybrids of rice.

Semisterility, induced by irradiation in rice, has been considered mainly due to the chromosome interchange evidenced cytologically by the orientation of quadrivalent chromosomes in PMCs and genetically by a 1 : 1 segregation of fertiles to semisteriles. The lower the frequency of ④ chromosomes formed in meiosis, the shorter the segments of chromosomes interchanged. The present authors attempted to isolate from the irradiated populations of rice semisterility segregating lines in which the chromosome behavior of sterile plants in meiosis appeared similar to that of the original variety.

The data, presented in this paper, showed that not all semisterilities derived from irradiated rice seed were caused by cytologically detectable translocations. There was an unexpected high percentage of semisterility lines that did not involve big chromosome changes, but involved small changes. The smaller the change occurred, the lower the degree of sterility was observed. The percentage of these semisterility segregating lines would even be higher, if relatively low dose of radiation was used. It seems that many, but not all, of no ④ semisterilities showed the same breeing behavior as those known in heterozygous translocation. Semisterility homozygotes, that were isolated, set seed normally and bred true in most of cases. The breeding behaviors of seed and pollen fertilities in the F_1's and F_2's between these homozygotes were similar to those reported in the intersubspecific hybrids of rice. Whether the semisterility of this nature exists in ordinary varieties is not answered in the present study. Investigating PMCs, pollen and seed fertilities of the F_1's between SH lines and ordinary indica varieties, in comparison with those F_1's that original Taichung 65 is a substitute of SH lines as a parent, may be useful in answering this question.

Types of rice mutants, induced by irradiation, are known to be similar with those of collected genetic stocks originated mostly from spontaneous mutations. Though this is not always true, there are various examples to support this view in rice, such as lazy type, narrow and rolling leaves, minute spikelet, chlorophyll deficiencies, various types of dwarfs, anthocyanin pigmentation, etc. , that have been found in irradiated populations and also in the ordinary genetic stocks (5). The most striking example, asdescribed by Li *et al.* (27), was that the semidwarf type induced by irradiation from tall Taiwanese indica varieties were found to be controlled by the semidwarf gene identical to those of existing semidwarfs. For this reason, more attention should be paid to the artificially induced sterility and semisterility caused by small structural changes and genic changes in discussing the origin of intersubspecific hybrid sterility. The evidences, obtained in this study, were in favor of translocations of small segments as the role of differentiation of rice subspecies in hybrid sterility. This view was first presented by Venkataswamy (1957) and later supported by Stebbins

(1958) and Shastry *et al.* (23). However, there was no evidence in this study to discard the gamete development gene theory presented by Oka (23) and the inversion view by Henderson (23).

Table 10. Segregation of seed fertility and good pollen ratio of the intercross F_2 populations between SH lines

Hybrid No.	Parent of the F_1			Number of plants in each seed-set interval (%)												Ave. in F_1 (%)
				95	85	75	65	55	45	35	25	15	5	Total	Average (%)	
F_2 1126	SH636-5	SH629-1	P :	30	8	23	31	22	25	12	4			155	65.3	50.9
			F :	17	14	16	22	22	23	23	28	3	1	169	54.6	24.2
F_2 1127	SH644-4	SH629-1	P :	44	17	28	41	32	28	6	2	1		199	68.8	45.8
			F :	24	14	12	33	22	28	11	37	25	8	214	50.0	27.9
F_2 1128	SH645-4	SH629-1	P :	20	7	11	7	17	10	14	4	2		92	62.8	47.5
			F :	9	6	5	12	18	9	15	16	4	1	95	51.6	37.0
F_2 1129	SH650-1	SH629-1	P :	9	9	4	14	17	24	15	7	5		104	54.0	45.6
			F :	6	3	7	14	17	13	19	13	10	3	105	47.0	24.7
F_2 1130	SH652-11	SH629-1	P :	40	31	75	34	23	6	2	1			212	75.0	48.7
			F :	15	18	12	56	38	20	29	10	1	4	203	58.1	42.3
F_2 1131	SH644-4	SH636-5	P :	17	2	9	15	27	14	3	4	3		94	61.7	42.2
			F :	9	8	10	9	24	9	2	4	8	5	88	55.8	14.9

P : =Good pollen ratio

F : =Seed fertility

Summary

Among the 87 X_3 lines of rice segregated for seed fertility, 22 were found normal in chromosome behavior at diakinesis or metaphase-I in both fertile and semisterile plants. The frequencies of the individual seedset percentages in most of these 22 lines distributed in continuous manners, otherwise in a ratio of 1 : 1. Semisterile plants of 1 : 1 segregating X_3 lines tended to produce progenies segregated in 1 : 1, while those of the continuously segregating lines showed relatively unstable breeding behavior.

The fertile plants in the stable X_4 lines were testcrossed on the original variety, Taichung 65, and 12 homozygotes that set seed normally and bred true were isolated. The similar segregation for seed fertility re-occurred in the respective testcross F_2.

The percentages of seed fertility and stainable pollen of the intercross F_1's between

these homozygotes were, respectively, 14.9%-42.5% and 31.9%-50.0%. Five to 15% of intermediately aborted pollen were observed in the F_1's related with specific homozygotes. The frequencies of seedset and stainable pollen percentages in most of the intercross F_2's distributed in continuous manners similar to those reported in the F_2 of the intersubspecific hybrid of rice.

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X光線誘發之稻染色體微小變異半不稔性之研究[1]

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中文摘要

1.本試驗以研究水稻品種臺中65號經X光線處理後誘發之半不稔性及其遺傳行動爲目的，尤其是以顯微鏡不易查出的染色體微小變異者爲對象。由10kr, 20kr, 30kr 處理過的 X_2 材料中逢機取出 $87X_3$ 半不稔系統，其中有22個系統分離半不稔個體而其花粉母細胞在肥厚期和第一中期只形成3%或以下的一個四價染色體，或者都是正常。這些系統可認爲染色體構造正常或發生微小變化者。

2.含有四價染色體的花粉母細胞之百分比少於3%的X_3半不稔系統，除了成以一比一分離結實與半結實個體外，尙有許多成連續性分離者。一比一分離系統內的半不稔個體大部分產生同樣分離之後代，但連續性分離者却產生四種不同分離型式之後代。

3.從四價染色體百分比低於3%的系統內，取其結實個體數株，並回交於原品種。根據此測驗交配的結果，分離出12個稔性正常又固定之同型接合體。連續性分離系統的測驗交配 F_1 有58.2%—64.8%之結實率，一比一分離系統的測驗交配F_1有44.4%—54.8%。上述稔性分離現象無論是一比一或連續者，都能於測驗交配F_2族羣中再度出現。

4.將上述12個同型結合體互相什交，結果互相什交F_1的結實率變異於14.9%—42.5%，而正常花粉率變異於31.9%—50.0%之間。此等F_1並沒有單性結果的現象。與一個同型結合體系統有親緣關係的F_1均發現有半退化花粉，約變異於5%—15%之間。

5.同型接合體間互相什交F_2族羣中，個體的結實率分離甚廣，與一般秈粳型稻品種間什交F_2者相似。至於此種半不稔性是否存在於天然品種之間，猶待今後之探求。

1.試驗報告農試字第六一七號

2.臺灣省農業試驗所技正，及前臺灣大學講師